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(21) International Application Number: PCT/US96/10587 (22) International Filing Date: 19 June 1996 (19.06.96) (30) Priority Data: 08/499,210 7 July 1995 (07.07.95) US (71) Applicant: PURDUE RESEARCH FOUNDATION [US/US]; 1650 Engineering Administration Building, Room 328, West Lafayette, IN 47907 (US). (72) Inventors: SINGH, Rakesh, K.; 3350 Putnam Street, West Lafayette, IN 47906-1276 (US). MURIANA, Peter, M.; 2013 Wake Robin Drive, West Lafayette, IN 47907 (US). STADELMAN, William, J.; 1429 North Salisbury, West Lafayette, IN 47906-2419 (US). HOU, Huiying; Apartment No. 7, 125 Marsham Drive, West Lafayette, IN 47906 (US). (74) Agents: LAMMERT, Steven, R. et al.; Barnes & Thornburg, 1313 Merchants Bank Building, 11 South Meridian Street, Indianapolis, IN 46204 (US).	(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>	
(54) Title: PASTEURIZATION OF SHELL EGGS (57) Abstract A process for pasteurization of intact shell eggs is provided wherein whole eggs are subjected to mild heat processing conditions effective to reduce or eliminate the microbial load in the egg white and egg yolk while retaining whole egg functionality and shelf life. The pasteurization process has been shown to effect up to an 8 log reduction in <i>Salmonella</i> load in <i>Salmonella</i> inoculated test eggs.		

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-1-

PASTEURIZATION OF SHELL EGGSField of Invention

5 This invention relates to the pasteurization of shell eggs. More particularly it is directed to a gentle heat treatment process for intact shell eggs to destroy existent micro-organisms while maintaining egg storage characteristics and the functionality of the contained egg white and egg yolk.

10

Background of the Invention

It has been estimated that more than 65 billion fresh shell eggs are sold annually in the United States. Raw eggs pose a serious health hazard to humans if they are contaminated with *Salmonella*, a pathogenic gram-negative rod-like bacteria, which originates from transovarian transmission to the developing preovulatory follicles in hen's ovary. *Salmonella enteritidis* is recognized as an egg-associated pathogen that has been implicated in foodborne disease outbreaks in several countries. *Salmonella enteritidis* infections have shown a dramatic increase due to consumption of raw eggs, or egg-containing undercooked foods, or cross-contamination between raw eggs and other cooked products. Although shell eggs are sanitized by washing and rapid chilling, these methods do not destroy *Salmonella* if it is harbored inside shell eggs. *Salmonella* on the surface of shell eggs has been decreased by washing with reduced pH water at moderate temperatures. The incidence of *Salmonella enteritidis* infected eggs in an infected flock of hens has been estimated to be about 0.5% with less than 100 CFU of *Salmonella enteritidis* per egg.

There has been a significant research and development effort directed to defining optimum conditions for liquid whole egg pasteurization. Pasteurization using heat is an effective method to destroy *Salmonella enteritidis* in

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-2-

liquid eggs. Generally, the temperature of liquid whole egg is controlled as the liquid is pumped through heat exchangers under turbulent conditions to avoid coagulation. U.S. Patent No. 3,573, 935 describes the use of alkali to
5 adjust pH of liquid eggs before heat pasteurization at 125 to 145°F (52 to 63°C) for 0.5 to 10 minutes. U.S. Patent No. 4,808,425 describes pasteurization of liquid whole eggs using a continuous flow, high temperature, short time process.

10 Shell egg pasteurization presents unique problems. Application of heat for pasteurization of intact shell eggs is challenging in the sense that the egg contents within the shell cannot be vigorously agitated as done for liquid whole eggs to promote heat distribution and avoid
15 coagulation of proteins. Heating of intact eggs creates a temperature gradient within the egg. To heat pasteurize the center of the egg, care needs to be taken not to overheat and possibly partially cook or denature the egg white near the shell.

20 The inherent problem of delivering heat to the yolk through the shell and the egg white and the need to maintain the quality of pasteurized shell eggs, particularly the functional properties (coagulation, foaming, and emulsification) of egg whites, impose
25 significant constraints on pasteurization processing of whole eggs. Some egg white proteins (i.e., ovalbumin and ovotransferrin) can be denatured at a temperature as low as 60°C. With continuous heating, chemical and physical interactions occur leading to the formation of protein
30 aggregates and concomitant loss of functionality. Furthermore, excess heat can also destroy or reduce activity of lysozyme, a natural defense mechanism in egg-white against gram-positive bacteria. Therefore, denaturation of lysozyme and consequent loss of whole egg
35 shelf life is also a concern in heat pasteurized eggs.

-3-

Generally, the use of heat for pasteurization, i.e., reduction of microbial load in whole eggs, is associated with loss of functional properties. There is a recognized need for a process which can work for pasteurizing intact
5 shell eggs without significant egg white protein denaturation.

Accordingly, it is one object of this invention to provide a method for pasteurizing intact shell eggs while retaining egg yolk and egg white functionality.

10 It is another object of this invention to provide a method for reproducing microbial load in whole intact shell eggs by a gentle, commercially adaptable heat treatment process with retention of shell egg storage characteristics.

15 In one embodiment of the present method shell eggs are heated by contact with a heat transfer medium having a relatively low controlled temperature, about 52° to about 59°C, alone or in combination with incident microwave or radiant heat energy. The heat transfer fluid can be a
20 liquid or a gas, most typically water or air. The heat transfer fluid can be agitated to reduce thermal gradients in the heat transfer fluid and improve heat transfer efficiency during egg heat treatment. Further, eggs in-process can be reoriented or repositioned continuously or
25 periodically, particularly during the heating step, to promote heat transfer from the egg surface to the yolk. The egg is heated until the yolk temperature is about 52 to about 59°C. The egg is held at that temperature for about 3 minutes to about 3 hours, depending on the selected
30 pasteurization temperature within the specified range, and thereafter cooled to a temperature of less than 7°C. Pasteurizing eggs in accordance with this invention, for example using a combination of hot water and hot air heating, reduces the microbial population in intact shell
35 eggs artificially inoculated with *Salmonella enteritidis* by

-4-

7 log cycles in 80 minutes. A combination of hot water and microwave heating has reduced the *Salmonella enteritidis* count in artificially inoculated intact shell eggs by 6 log cycles in about 30 minutes with but minimal loss of functionality of the contained egg white and egg yolk as measured by standard tests including Haugh unit value, foaming ability and stability, viscosity, yolk index, turbidity, pH, color and lysozyme activity.

10 Brief Description of the Drawings

Fig. 1 is a graph of microbial count vs. temperature in intact shell eggs heated in hot water;

Fig. 2 is a graph of microbial count vs. temperature in intact shell eggs heated with hot air;

15 Fig. 3 is a graph of microbial count vs. temperature of intact shell eggs heated to a temperature in hot water and held at temperature in hot air;

Fig. 4 is a graph of microbial count vs. temperature increase in intact shell eggs during microwave heating;

20 Fig. 5 is a graph showing temperature profile and microbial count reduction as a function of time during combination of microwave (high power) and hot water bath heating of shell eggs;

25 Fig. 6 is a graph showing temperature profile and microbial count reduction as a function of time during combination of microwave (high power for 80 sec) and hot air heating of shell eggs;

30 Fig. 7a is a graphic comparison of Haugh units and pH of egg whites before and after pasteurization with hot water and hot air in accordance with this invention;

Fig. 7b is a graphic comparison of turbidity and yolk index of egg whites before and after pasteurization with hot water and hot air in accordance with this invention; and

-5-

Fig. 8a is a graph showing the difference in foam drainage of whipped egg white of fresh eggs and pasteurized eggs in accordance with this invention.

Fig. 8b is a graph showing the differences in foaming height of whipped egg white of fresh eggs and pasteurized eggs in accordance with this invention.

Detailed Description of Invention

In accordance with the present invention intact shell eggs are heat pasteurized by heating the egg under controlled conditions to raise the temperature of the yolk of the egg to about 52° to 59°C, at which temperature the egg yolk is maintained for a period of about 3 minutes to about 3 hours. Thereafter the egg is cooled to a temperature below about 7°C. The time and temperature requirements for acceptable pasteurization are generally inversely proportional within the stated ranges for those process parameters. Thus, at the lower end of the temperature range, i.e., at about 52-55°, longer times within the time range, i.e., about 1 to about 3 hours, are optimally effective while shorter times, for example, about 3 minutes to about 1/2 hour, are effective to achieve pasteurization at temperatures 57-59°C. Following the heating step, the egg is then cooled to a temperature of less than about 7°C.

In accordance with this invention heat is delivered to the yolk of a whole intact egg in amount sufficient to destroy microbial content of both the egg white and egg yolk without denaturization of the more heat sensitive egg white. Heat is delivered to the egg white and egg yolk either through the surface shell by incident radiant energy or contact of the shell with a temperature controlled heat transfer fluid or by incident microwave energy. The pasteurization process must be accomplished in a manner which minimizes the possibility of localized superheating

-6-

(cooking) of the egg white, and preferably in a manner which optimizes the rate of heat transfer from the heat source to the yolk. Thus, in carrying out the present invention the amount of heat delivered to the surface of the egg cannot exceed the amount which raises the temperature of the egg white adjacent the shell inside the egg above about 60°C. Such requirements dictate good control of egg pasteurization processing operations.

Thus in one embodiment of this invention the amount of heat energy delivered to the intact egg is controlled through the temperature of the heat transfer fluid used to deliver heat energy to the egg. The temperature of the heat transfer fluid is preferably maintained between about 52°C and about 59°C. Advantageously the heat transfer fluid is mechanically agitated with, for example, a motor driven impeller or pump, to circulate the fluid across the surface of the in-process eggs. Such agitation works to maintain a maximum thermal gradient between the heat transfer fluid and the egg shell and enhances the rate of heat transfer to the egg from the fluid.

When radiant energy or microwave energy is utilized to heat intact shell eggs in accordance with this invention, localized superheating within the eggs undergoing heat pasteurization can be minimized by periodically or continuously reorienting, (e.g., rolling and/or spinning on axis), and/or repositioning (e.g., on a turntable or moving belt) the egg relative to the source of radiant or microwave energy. In one embodiment of the present invention, microwave or radiant energy, preferably microwave energy, is utilized to preheat the shell egg to a predetermined temperature near, but below pasteurization temperature, and the egg is thereafter placed in contact with a temperature controlled heat transfer fluid to bring the eggs contents to pasteurization temperature and to hold the egg contents at temperature for a time sufficient to

-7-

effectively reduce or eliminate any existent microbial load in the egg. Such two-stage processing takes advantage of both the heating efficiency/rate of microwave systems and the temperature control advantages of using a controlled temperature heat transfer fluid. Other multi-stage heating operations can be utilized to take advantage of existing egg processing plant equipment and energy sources.

Reorienting or repositioning the egg during the heating step facilitates dissipation and transfer of heat energy delivered to the egg surface into the yolk. Thus during the heating step, whether it be carried out utilizing microwave or radiant energy, or by immersion in a temperature controlled heat transfer fluid, the egg can be periodically or continuously reoriented and/or repositioned to enhance the efficiency and rate of heat delivery to the egg yolk thereby reducing the time required to bring the egg yolks to the specified pasteurization temperature. In-process eggs can be reoriented, for example, by rolling on an inclined or a moving surface, for example a motor-driven belt, in one direction, or in alternating directions, or the eggs can be repositioned, for example, by shaking or rocking the carrier, or the in-process eggs can be positioned for movement responsive to localized force on the egg from agitated heat transfer fluid in contact with the egg. The resulting motion of the egg is translated into movement of the egg white and yolk within the shell which movement promotes dissipation of heat delivered through the surface of the egg and transfer of same to the inner yolk. Such movement not only minimizes the potential for localized denaturization of egg white protein, but it also works to dissipate heat energy delivered to the shell and enhance the thermal gradient between the heated shell and the liquid portion of the egg during heating and thereby improve heat transfer rate and reduce total egg processing time.

-8-

The present process can be carried out in batch or continuous processing as part of a commercial egg processing line using art recognized commercial egg handling techniques and equipment. Egg pasteurization can be accomplished using temperature controlled ovens or water baths, preferably fitted with impellers to promote agitation of the heat transfer fluid. Alternatively, conventional microwave or radiant heating equipment can be utilized to heat eggs in a batch or continuous process wherein the eggs are repositioned or rotated in the incident microwave or radiant energy field. Thus, for example, eggs can be placed on an inclined trough or platform and rolled under the influence of gravity through a controlled heat delivery zone. Different types of heating equipment may be used in combination for carrying out the present process. Thus, microwave or radiant energy can be used to preheat the eggs, a liquid or gas heat transfer medium can be used to bring the eggs to pasteurization temperature, and the same or a different heat transfer fluid can be used to maintain egg temperature, for the required time to accomplish pasteurization.

The final step in processing eggs in accordance with this invention, prior to packaging and storage for shipment, is to cool the eggs to a temperature of about 7°C or lower. That is accomplished by contacting the eggs with a fluid, either gas or liquid, having a temperature of less than about 7°C.

EXAMPLE 1

Equipment and supplies:

Panasonic microwave with turntable.

Digital thermometer in Celsius.

Day old eggs.

-9-

Procedure:

One egg was heated in the microwave with power on medium low setting (defrost) for 60 seconds, 75 seconds and 90 seconds. Other eggs were heated with the microwave set on medium heat for 40, 45, 60, and 75 seconds. Temperatures in all yolks and albumens were determined immediately after microwave heating.

Results:

	Power setting	Time (Seconds)	Temperature (Celsius)	Material
10	Medium low (defrost)	60	45	Albumen
	"	60	52.1	Yolk
	"	75	45	Albumen
15	"	90	61.7	Yolk
	"	90	45.7	Albumen
	Medium	40	38.3	Albumen
	"	40	49	Yolk
	"	45	50.9	Albumen
20	"	45	57.2	Yolk
	"	60	60.9	Albumen
	"	60	67.8	Yolk

Conclusion:

Microwave heating set on medium power for 45 seconds could be used for heating intact eggs to pasteurizing temperatures. Optimum results (no localized egg white denaturization) can be obtained by rotating or otherwise changing the orientation of the eggs during microwave heating.

EXAMPLE 2**Equipment and supplies:**

Waterbath with thermostat capable of holding within + or - 0.1 C.

Digital thermometer.

Day-old eggs.

-10-

Procedure:

Waterbath temperature was set at 57 C. Eight eggs were immersed in the water. Initial temperature of egg contents was 7°C. Temperatures of yolk and albumen of two eggs were taken after 15, 20, 25, and 30 minutes.

Results:

Temperatures of yolk and albumen of individual eggs are listed below in tabular form:

With temperatures in Celsius and time in minutes:

Times	15	20	25	30
Yolk				
Egg 1	55.6	57.0	56.6	57.1
Egg 2	54.6	55.9	56.0	57.0
Albumen				
Egg 1	53.9	53.9	56.4	56.7
Egg 2	54.6	54.1	54.3	56.7

Conclusions:

Under static conditions egg contents can be heated to near the water temperature in 15 to 20 minutes.

EXAMPLE 3

Fresh eggs were inoculated with *Salmonella enteritidis* to give a count of 400,000 cfu/ml. Following the procedure of Example 2 the eggs were heated in a laboratory batch pasteurizer set at 57°C and sampled at various time intervals. Similarly, un-inoculated eggs with thermocouples placed at their center were also heated and the temperature profile was recorded. As shown in Fig. 1, the temperature of eggs increased to the set temperature of hot water in 25 minutes and during the same period the *Salmonella* counts decreased from 400,000 to 300 cfu/ml which is close to a three log-cycle reduction.

EXAMPLE 4**Equipment and supplies:**

Hot air oven.

-11-

Digital thermometer.

Streptomycin resistant *Salmonella enteritidis*
inoculated eggs.

Day-old eggs.

5

Procedure:

A dozen eggs inoculated with about 5 million colony forming units (CFU) of *Salmonella enteritidis* were placed in a hot air oven set at 56.6°C. An additional dozen of
10 non-inoculated day-old eggs were also placed in the oven. Temperatures of egg yolk and bacterial counts were taken at several time intervals during the 3 hour study.

Results and conclusions:

15 The temperatures and bacterial counts are shown in Fig. 2 A reduction of over 5 log cycles was achieved in CFU of *Salmonella enteritidis*. The slow heating extends the total time needed excessively. The heating time could
20 likely be reduced significantly if a turbulent air oven could have been used in place of the still air oven used.

EXAMPLE 5

Equipment and supplies:

Waterbath.

25 Hot air oven.

Digital thermometer.

Streptomycin resistant *Salmonella enteritidis*
inoculated eggs.

Day-old eggs.

30

Procedure:

Salmonella enteritidis inoculated eggs were heated in the water bath set at 57°C for 25 minutes and then placed in the hot air oven set at 55°C for an additional 60

-12-

minutes. Non-inoculated eggs were used to determine temperatures at various times.

Results:

5 The temperatures and colony forming unit (CFU) counts of *Salmonella* are shown in Fig. 3. The slight decline in temperature at the time of transfer was likely due to evaporative cooling of the eggs during surface water evaporation.

10

Conclusions:

 A seven log cycle destruction of *Salmonella enteritidis* was obtained after 85 minutes. Hot water and hot air heating appear to be satisfactory methods of
15 heating eggs to pasteurizing temperatures. A holding time after reaching a yolk temperature of 55°C of 1 hour is adequate for a seven log cycle destruction of *Salmonella enteritidis*.

20

EXAMPLE 6

 The intact eggs were heated in a microwave oven set at high power level and sampled at various time intervals. As shown in Fig. 4, the temperature of egg increased to about 60°C in 120 seconds. The microbial count decreased from
25 8×10^6 to 10^4 during that time period. The decrease in SE population during microwave heating without any hold time was not enough for pasteurization.

 The procedure for shell egg pasteurization was extended to include microwave followed by hot water
30 heating. Under this condition, the microwave energy increased the egg temperature to desired level quickly and the hot water system was used for providing hold time at that temperature. See Fig. 5. This combination shortens the total time required for pasteurization of shell eggs.
35 Similarly, a combination of microwave energy followed by

-13-

holding in hot air chamber provides pasteurization of intact eggs. See Example 7 and Fig. 6.

EXAMPLE 7

5 Equipment and supplies:

Panasonic microwave with turntable.

Digital thermometer.

Hot air oven with +/- 00.5 C controls.

Salmonella enteritidis inoculated shell eggs.

10 Day-old eggs.

Procedure:

Shell eggs were inoculated with ten million colony forming units (CFU) of a streptomycin resistant strain of *Salmonella enteritidis* which had been grown in egg yolk. One dozen of these eggs were heated in the microwave for 80 seconds with a high power setting. Hot air oven temperature was set at 56.5 C. After heating eggs in the microwave they were immediately placed in the hot air oven.

20

Results:

Yolk temperature and bacterial counts over time to 120 minutes are shown in Fig 6.

25 Conclusions:

A combination of microwave heating and hot air holding resulted in over a 5 log cycle reduction in bacterial numbers. As the usual numbers of *Salmonella enteritidis* in fresh eggs are less than 100 per contaminated egg, this process gives over a 3 log cycle safety margin. A higher power level or longer microwave exposure could be used to reduce heating time to a few minutes to reduce total time necessary for adequate destruction levels of *Salmonella enteritidis* organisms.

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-14-

EXAMPLE 8

Equipment and supplies:

Control and pasteurized eggs.

Egg yolk separator.

5 Kitchen-Aide mixer with bowl and attachments.

Metric ruler.

100 ml. graduated cylinder, funnel, and wire mesh.

Procedures:

10 Control and pasteurized eggs were kept separate and broken so as to separate yolks and albumen to get albumen entirely free of yolk material. The temperature of all eggs was at 22°C, room temperature at the time of breaking and separating. Four hundred fifty grams of each type of

15 albumen, control or pasteurized, were whipped in the Kitchen-Aide mixer for 90 seconds at speed 2 and then for 90 seconds at speed 3. The wire whip was removed, the foam surface leveled and depth was measured. The foam was then placed on a wire mesh over a funnel leading to a graduated

20 cylinder and allowed to drain for 25 minutes.

Results:

The results of the volume and drainage tests are shown in Fig. 8b and Fig. 8a respectively.

25

EXAMPLE 9

Equipment and supplies:

The physical properties, including Haugh units and pH (See Fig. 7a) and turbidity and yolk index (See Fig. 7b)

30 were determined for egg white before and after pasteurization with hot water and hot air. Each of the tests on functionality and physical qualities required special equipment. In all cases the equipment was appropriate for the test involved.

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-15-

Haugh Units and Yolk Index:

Haugh meter - a tripod micrometer calibrated to read
in Haugh units and a tripod micrometer.

A vernier caliper.

5 Egg breaking stand equipped with flat glass surface.
Gram scales.

Chart to convert gram weights to ounces per dozen.

Day-old eggs, controls and pasteurized.

10 **Procedure:**

Haugh Units:

Individual eggs of controls and pasteurized groups
were weighed, broken carefully on the breaking stand, and
height of the thick albumen was measured. Results were
15 recorded and averages and standard deviations calculated.

Yolk Index:

The height of the yolk and its width in two directions
at right angles from each other were measured. Results
20 were recorded, yolk indices were calculated by dividing the
height by the average diameter and applying the appropriate
correction for variations in Haugh units. Averages and
standard deviations were calculated.

Statistical significance of differences were
25 determined.

Results and conclusions:

Haugh units measurements were not significantly
different between the controls and the pasteurized eggs
30 (Fig. 7a). Tests were conducted on several days. Values
for controls were 70.3, 66.0, and 69.1 with SD values of
3.0, 10.7, and 9.7, respectively. for the pasteurized eggs
Haugh units were 75.3, 74.9, and 74.7 with SD values of
5.9, 12.1, and 7.2, respectively. Differences were not
35 statistically significant.

-16-

Yolk index values were .41 for controls and .36 for the pasteurized eggs, not significantly different. (Fig. 7b).

-17-

CLAIMS

1. A method for pasteurizing intact shell eggs while retaining egg yolk and egg white functionality and shell
5 egg storage characteristics said method comprising the steps of
 contacting the egg with a heat transfer fluid having a controlled temperature of about 52° to about 59°C for a period of time sufficient to raise the temperature of
10 the yolk of the egg to about 52° to about 59°C; and
 holding the heated egg in contact with the temperature controlled heat transfer fluid for about 3 minutes to about 3 hours, and thereafter cooling the egg to a temperature of about 7°C or below.
- 15 2. The method of claim 1 wherein the controlled temperature heat transfer fluid is agitated to minimize thermal gradients in the fluid.
3. The method of claim 1 further comprising the step of preheating the egg with microwave energy.
- 20 4. The method of claim 1 further comprising the step of changing the position or orientation of the egg while it is in contact with the temperature controlled heat transfer fluid.
5. The method of claim 3 further comprising the step
25 of changing the position or orientation of the egg during preheating.
6. The method of claim 1 wherein the temperature of the controlled temperature heat transfer fluid is about 52 to about 59°C.
- 30 7. The method of claim 5 wherein the controlled temperature heat transfer fluid is agitated to minimize thermal gradients in the fluid.
8. The method of claim 6 further comprising the step of changing the position or orientation of the egg during
35 heating.

-18-

9. A method for pasteurizing intact shell eggs while retaining egg yolk and egg white functionality and shell egg storage characteristics said method comprising the steps of

5 heating the egg by contacting the egg with 1) incident microwave or radiant energy or 2) a heat transfer fluid having a controlled temperature of about 52 to about 59°C, until the temperature of the yolk of the egg is about 52° to about 59°C;

10 maintaining the temperature of the yolk at about 52° to about 59°C for a period of about 3 minutes to about 3 hours; and

cooling the egg yolk to a temperature of about 7°C or below.

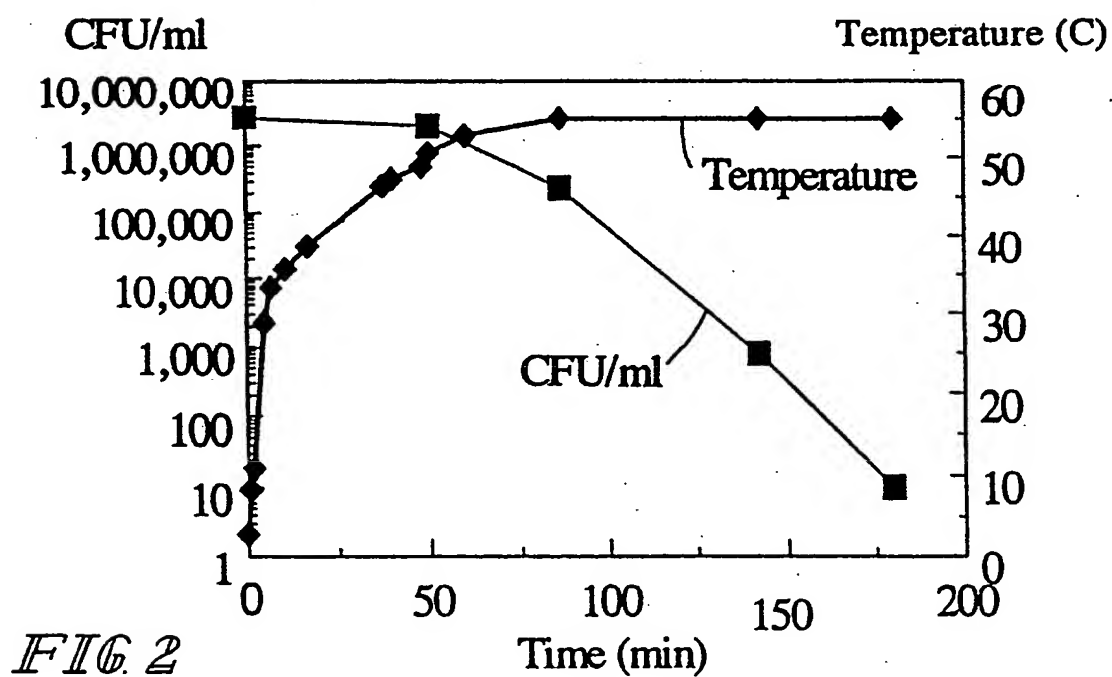
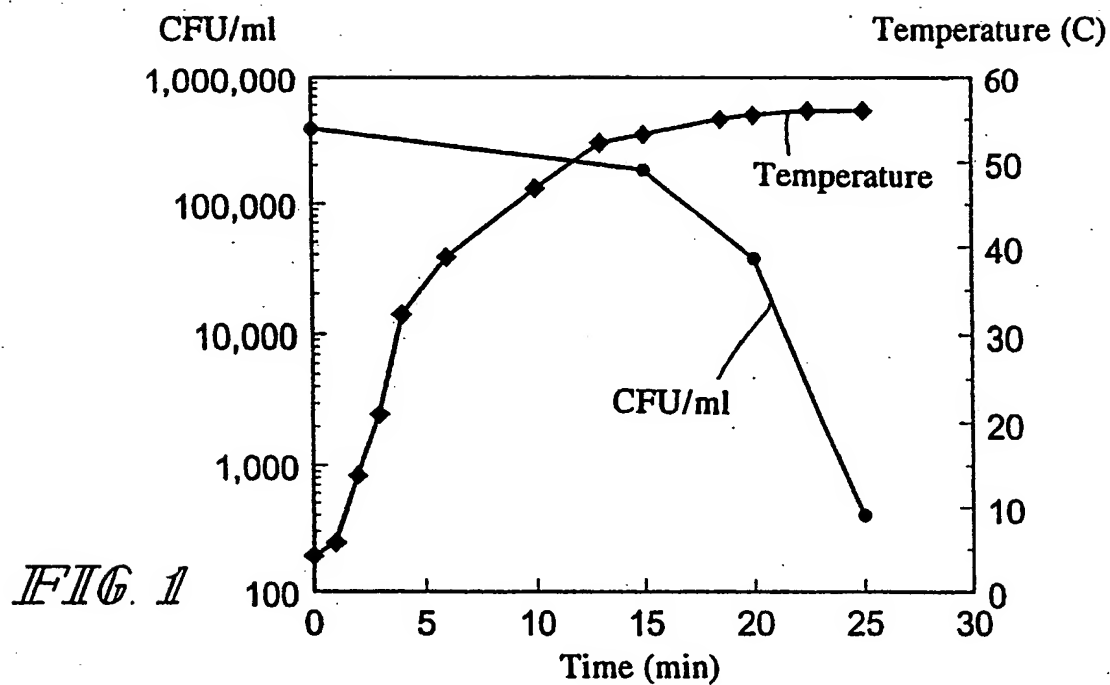
15 10. The method of claim 9 wherein the egg is contacted with microwave or radiant energy and a heat transfer fluid to raise the temperature of the yolk.

11. The method of claim 9 wherein the temperature of the yolk is maintained by contacting the egg with air or
20 water having a controlled temperature of about 52 to about 59°C.

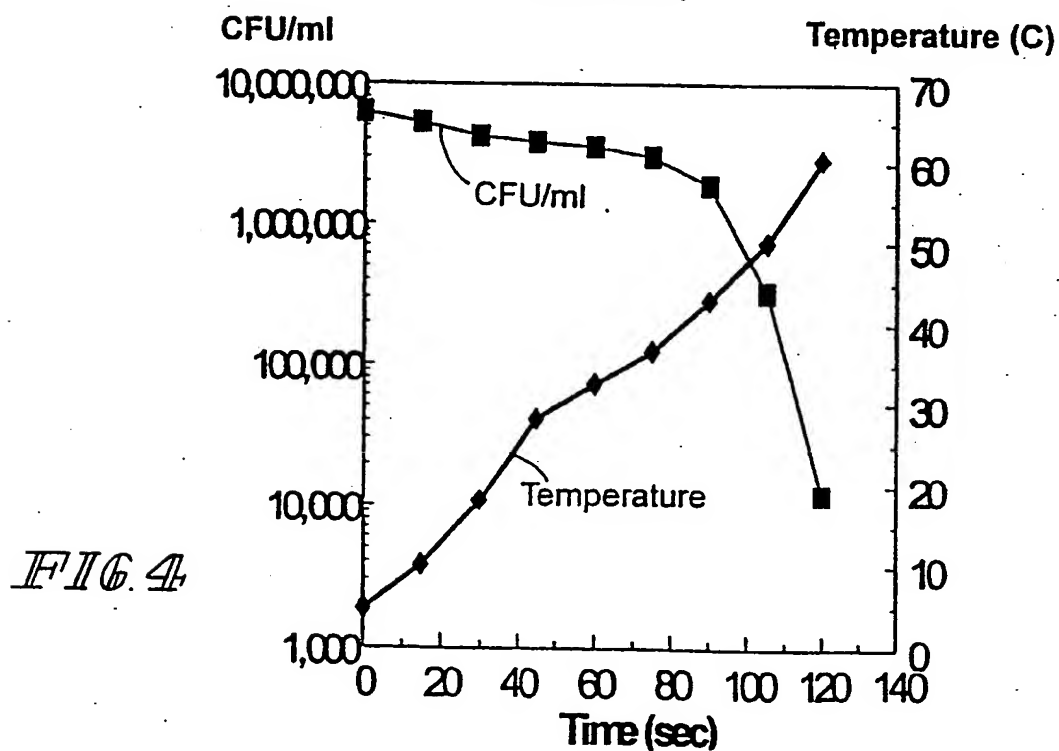
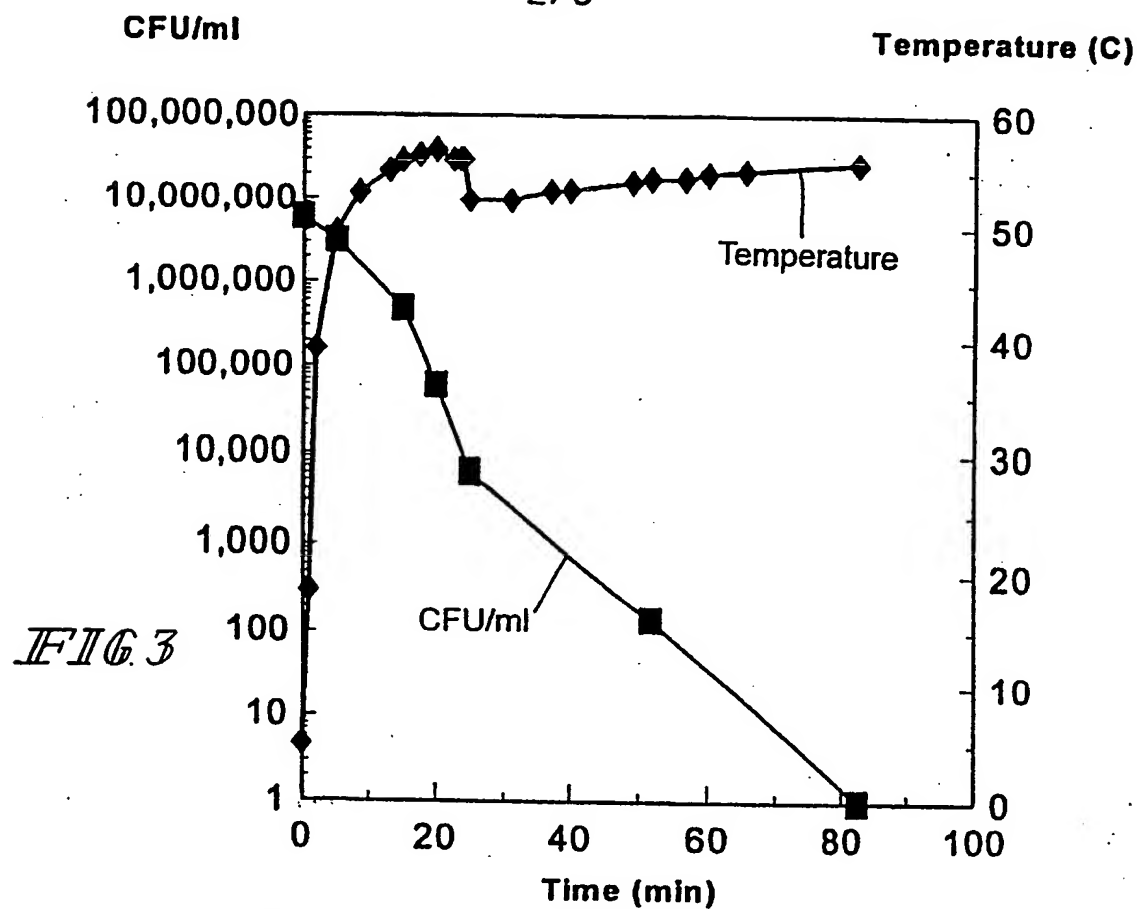
12. The method of claim 9 wherein the heating step comprises contacting the egg with a heat transfer fluid agitated to minimize thermal gradients in the fluid.

25 13. The method of claim 9 wherein the position or the orientation of the egg is changed during the heating step.

1/5



2/5



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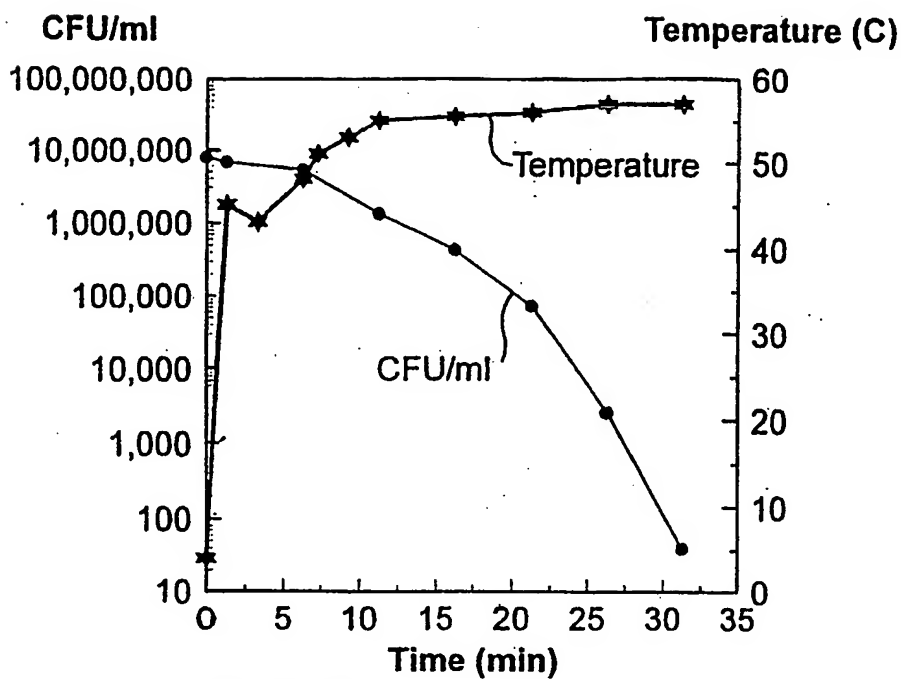


FIG. 5

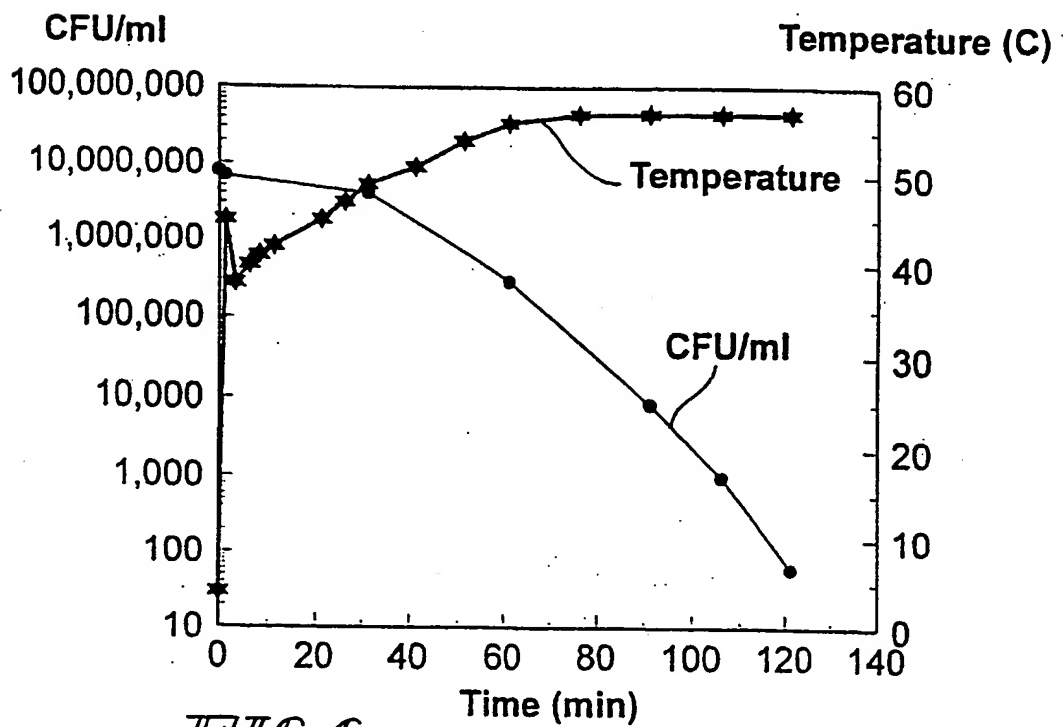
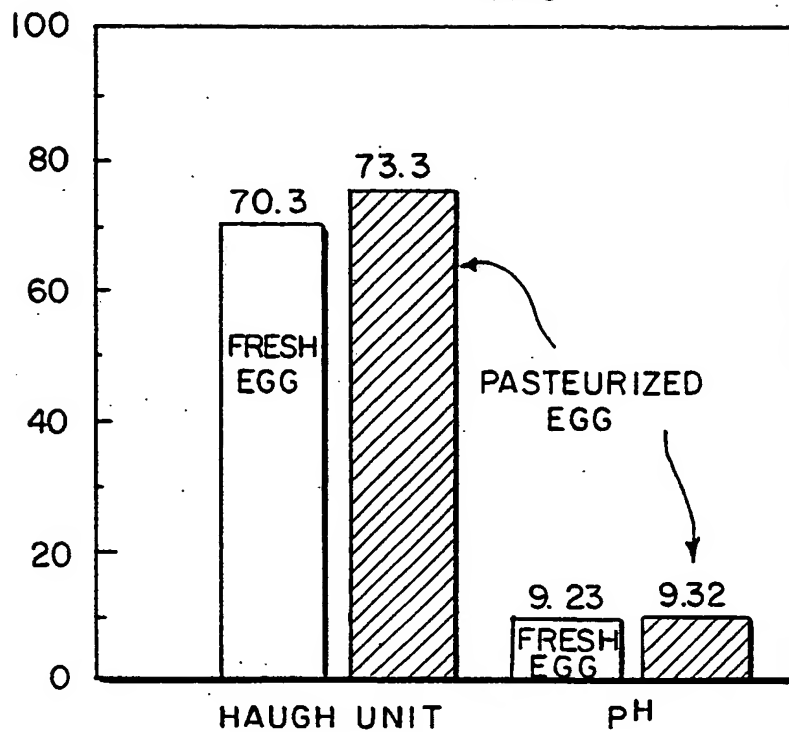
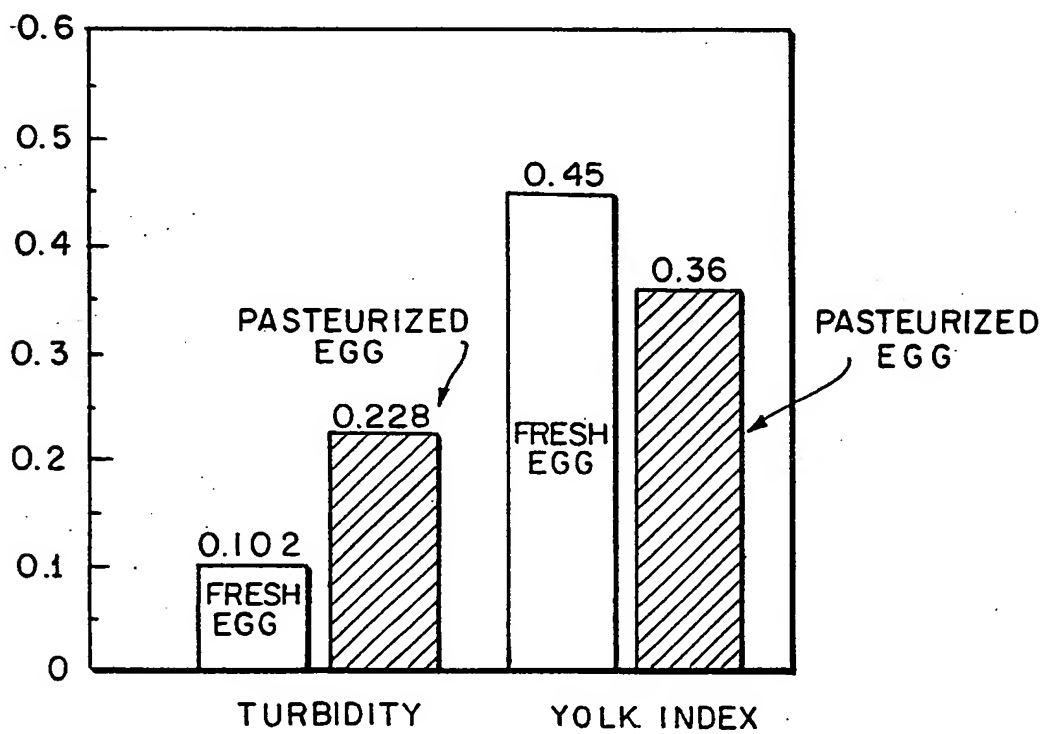


FIG. 6

4 / 5

*FIG 7a**FIG 7b*

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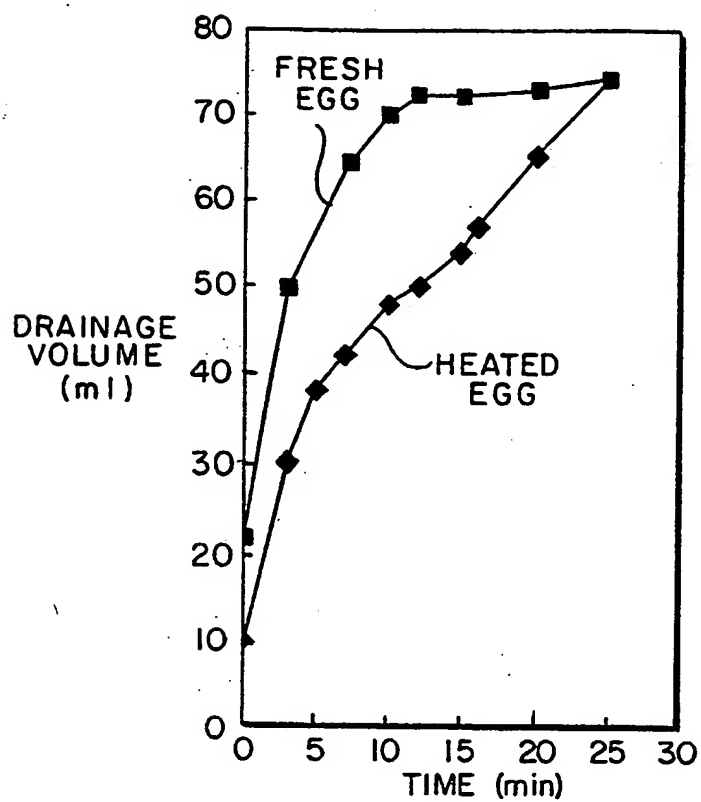


FIG. 8a

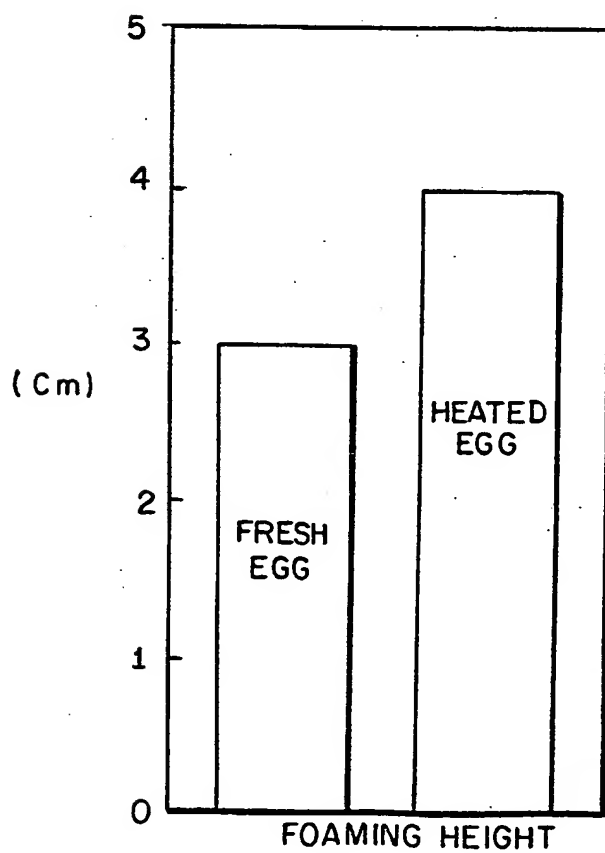


FIG. 8b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/10587

A. CLASSIFICATION OF SUBJECT MATTER IPC(5) : A23B 5/005; A23L 1/32 US CL : 426/ 241, 298, 300, 521 614 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) U.S. : 426/ 241, 298, 300, 521 614 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO, A, 95/14388 (COX ET AL) 01 JUNE 1995, SEE ENTIRE DOCUMENT.	1-13
Y	WO, A, 95/10943 (HAMID-SAMIMI ET AL) 27 APRIL 1995, SEE ENTIRE DOCUMENT.	1-13
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
A	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
E	earlier documents published on or after the international filing date	X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
L	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
O	document referring to an oral disclosure, use, exhibition or other means	
P	document published prior to the international filing date but later than the priority date claimed	2 document member of the same patent family
Date of the actual completion of the international search 08 AUGUST 1996		Date of mailing of the international search report 05 SEP 1996
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